PATENT SPECIFICATION

1,128,764

DRAWINGS ATTACHED

1,128,764

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COMPLETE SPECIFICATION

Improvements in and relating to an Inflatable Article such as an Air Mattress

We, ETABLISSEMENTS PENNEL & FLIPO, a French Body Corporate, of 143, Rue de Constantine, Roubaix (Nord) France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The rubberized fabric employed in the manufacture of inflatable articles such as air mattresses, pillows, cushions and the like is a material having little extensibility. The Applicant has discovered that the comfort of an inflatable article, and more particulary an air mattress, can be greatly improved by employing as the material a fabric which is at least partially elastic or extensible known *per se*.

The object of the invention is therefore to provide a new application of elastic fabrics in the form of an inflatable article constructed at least partially from a fabric having a coating containing an elastomer or plastomer and having an elasticity in at least one direction. The expression "fabric" is intended to be understood in the widest sense, that is, it designates not only fabrics obtained by weaving but also for example knitted, run-resistant, interlock and jersey fabrics and non-woven fabrics. As concerns the notion of elasticity it will be explained in the ensuing description of investigations and tests carried out by the Applicant.

1) Definition of comfort.

There are two fundamental conditions as concerns comfort:

a. In a given position of the sleeper, the comfort, which may be termed static comfort, is the greater as the enveloping of the sleeper is greater. In other words, in the most favourable case, the weight of the sleeper is distributed over the largest area of the body and under these conditions the unit pressure to which each part of the body is subjected—which is the ratio between the weight P of the sleeper and the surface of contact S—is minimum.

This pressure $p'=\dfrac{P}{S}$ is a measure of the hardness or "discomfort" of the mattress.

In the case of an air mattress this pressure p′ is identical at all points of contact and equal to the internal pressure of the mattress during use, which differs from the initial inflation pressure *p*.

b. From the dynamic point of view, in the event of a movement of the user on the mattress, a large increase in the pressure or particular points of high pressure should not be produced. In particular, as in the case of a conventional mattress inflated only to a slight extent, to satisfy the condition of static comfort, the elbow must not reach the ground through the mattress.

For a mattress of conventional type, experience has shown that contact with the ground through the mattress is avoided if this mattress is inflated beyond a limit value L.

Under these conditions, the comfort in motion is achieved when:

$$p \geqslant L$$

In practice, L is chosen between 8 and 20 g/sq.cm. depending on the height of the mattress.

It will be observed that in the present study what is termed pressure designates in fact an overpressure with respect to the external pressure.

2) Study of the comfort of a conventional air mattress.

The pressure of utilization p′ is distinctly greater than the inflation pressure. For example, a mattress inflated at a pressure p=20g/sq.cm. would easily have a pressure of utilization p′=60 g/sq.cm., which is the measure of the discomfort of the mattress. It is therefore of interest to decrease the value p′.

The value p′ is successively calculated as a function of the value p and the minimum value of p′ is determined knowing the minimum extreme value L of p.

Take the case of an air mattress composed of parallel elongated air compartments of equal height. The sleeper will be likened to a load P which is evenly distributed over the entire area of the elongated compartments.

Let:

G be the weight supported by 1 cm of air compartment (namely the weight P of the sleeper divided by the length of contact).

A the atmospheric pressure.

R is the initial radius of the inflatable air compartments.

The following expression is obtained with a very good approximation:

$$p'^3 - pp'^2 = h^3 \qquad \text{(I)}$$

with

$$h = \sqrt[3]{\frac{G^2 A}{R^2 \pi^2}} \qquad \text{(II)}$$

Note that h has a simple physical signification: it is the pressure of utilization of the mattress inflated at zero pressure on which the load under question is applied.

The equation (I) can be written as follows:

$$\left(\frac{p'}{h}\right)^3 - \frac{p}{h}\left(\frac{p'}{h}\right)^2 = 1$$

and corresponds graphically to the theoretical curve (A).

It will be observed that the static behaviour of the air mattress is perfectly defined when the value h is known, which depends only on the radius of the air compartments and the unit load supported per centimeter of air compartment.

It will be observed from the curve (A) not only that the pressure of utilization p′ is always higher than the inflation pressure p but that the difference between these two pressures is the greater as p is smaller.

3) Study of the comfort of a mattress according to the invention:

A study will now be made of what increase in comfort can be reached in employing a fabric having, in the range of tensions corresponding to the usual pressures of utilization, an elasticity in the transverse direction of the mattress, over a conventional mattress in which the tensions created by the inflation result in a small elongation which is without noticeable influence on the comfort.

Thereafter, what this elasticity must be to obtain maximum comfort of the mattress will be determined.

In respect of the initial pressure p and pressure of utilization p′, the gummed fabric is subjected to the following tangential forces:

$$f = p\ R \text{ and } f' = p'\ R'$$

where R and R′ are the radii of the elongated air compartments.

A coefficient of mean elastic elongation α can be defined in the range of the forces f and f′ by the expression:

$$l_1 = l_o\ (1 + \alpha f)$$

in which l_o and l_1 represent the length of a unit width segment of fabric measured in the direction of the forces respectively in the state of rest and in respect of the value f of the force.

To calculate p′ as a function of p, experimental observation is employed which can be checked from the curves to which references will be made hereinafter and according to which the pressure of utilization p′ varies as a function of p in the same way as a conventional mattress. In other words, there is roughly obtained again:

$$p'^3 - p\ p'^2 = h^3$$

But in this case h depends on the coefficient of elongation α.

h can be calculated as before:

$$h^3 = \frac{G^2 A}{\pi^2 R^2} \quad \frac{1}{1 + 2\alpha AR}$$

The foregoing expression can be written very simply.

If in a conventional mattress the pressure of utilization with zero initial pressure is h_c, the pressure of utilization for an elastic mattress with zero initial pressure (which is characteristic of the comfort of the mattress) would be h_E, so that:

$$h_E{}^3 = \frac{h_c{}^3}{1 + 2\alpha AR}$$

4) Elastic fabrics employed in accordance with the invention:

In respect of a radius of the elongated air compartments of between 5 and 10 cm and a pressure of utilization of between 20 and 100 g/sq.cm., the forces supported by the fabric are:

minimum: 0.1 kg/cm.
maximum: 1.0 kg/cm.

Let it be supposed that the improved comfort of the mattress would only be achieved if the values of the pressure of utilization p′ are reduced by at least 20%.

Whence a minimum value of the coefficient of elastic elongation α determined by:

$$\left(\frac{h_C}{h_E}\right)^3 - (1{\cdot}2)^3 = 1 + 2\alpha AR$$

Whence a=5% per kilogram of load when R=8 cm.

No fabric at present employed in inflatable articles satisfies this minimum condition of comfort, these fabrics having a coefficient α of the order of 0.5%.

According to the invention it is possible to obtain a comfort greatly exceeding this minimum.

Let it be assumed that the optimum static comfort is given by a mattress according to the invention which, under the weight of the sleeper, behaves as a conventional mattress which supports a sleeper of the same size but having half the weight.

If h_o is the value of h for the conventional mattress, which defines the behaviour of the mattress:

$$h_o^3 = \frac{G^2A}{\pi^2R^2}$$

For half the weight $(G \rightarrow \frac{G}{2})$ h_o^3 becomes

$$\frac{h_o^3}{4}$$

The elastic mattress must therefore have a value of h given by:

$$\frac{h_o^3}{h_E^3} = 4$$

$$1 + 2\alpha RA = 4 \qquad \alpha = 19\%/\text{kg.}$$

A strip 1 cm wide of gummed or rubberized fabric must have an elongation of 19% under the action of an overload of 1 kg.

It has been seen hereinbefore that the comfort in motion is obtained on condition that the mattress is inflated above a limit value below which the body would be liable to encounter the ground through the mattress.

If the following numerical values are taken:

Force applied per 1 cm of air compartment G=200 gram/cm

Radius of the air compartments R=8 cm

There is obtained: h_E=25 grams/sq.cm (elastic mattress α=19% per kg) h_c=40 grams/sq.cm (conventional mattress)

The following table gives the calculated values of the initial inflation pressures of the mattress in respect of several pressures of utilization.

Pressure of utilization p′ (gram/sq.cm.)	30	35	40	45	50	60
Inflation pressure of a conventional mattress (p)	impossible	impossible	0	13	30	42
Inflation pressure of the elastic mattress according to the invention (p)	12.5	22	30	37	44	56

It is impossible to employ the mattress according to the invention inflated to a greater extent initially to obtain the same static comfort (p′). In other words, the elastic mattress provides both static comfort and comfort in motion.

As concerns a large-size mattress, the inflation pressure of 13 gm/sq.cm is sufficient to ensure the comfort in motion

The pressure of utilization is then:

For the conventional mattress: 45 gm/sq.cm.

For the elastic mattress: 30 g/sq.cm.

5) *Examples*:

a. Elastic cotton-nylon fabric coated with rubber.

The support or base is a woven fabric the warp of which is of cotton and has low elasticity. The weft is of foam nylon and has within the range of utilization of air mattresses (0—1 kg/cm) a mean elasticity characterized by a coefficient α of 27% per kilogram, as shown on the curve B of Fig. 2, which indicates the elongation as a function of the force in kg/cm in respect of a specimen 4 cm wide.

b. Cotton-jersey fabric coated with rubber.

The warp is in this case of noticeable elasticity, (see curve C_o Fig. 2). The mean elasticity of the weft is indicated by curve C_1, Fig. 2.

c. Interlock fabric coated with polyvinyl chloride.

The warp has also a noticeable elasticity (see curve D_o Fig. 2.) The mean elasticity in the weft direction is indicated by curve D_1, Fig. 2.

d. Among other elastic fabrics there may be mentioned:

A run-resistant nylon fabric.

A cotton fabric rendered elastic by a treatment consisting in shrinking the fabric by damping and fixing this shrinkage by a treatment with a resin having a certain extensibility.

It will be understood that an inflatable article according to the invention can have one face of elastic fabric and another face of non-elastic fabric.

6) Characteristics and composition of the coating mixture.

Apart from the conventional properties required by known air mattresses, the coating containing an elastomer of the elastic fabric employed according to the invention must have special properties which can be analysed as follows:

a) The elongation at rupture must be high so that the coating can follow without rupture and without loss of impermeability, the higher elongation permitted by the elastic fabric.

An elongation at rupture between 500 and 900%, and preferably of the order of 800%, gives satisfactory results.

b) The mixture must have high elasticity, that is, must be capable of resuming its initial dimensions as quickly and as completely as possible after removal of the force which created its deformation.

This characteristic must impart to the mattress great rapidity of response to any movement of the user so that the mattress immediately adapts itself to the new position of the user and furthermore does not have permanent deformations after use.

The elasticity of the mixture can be defined by the permanent elongation of a specimen after a traction test which could be carried out until rupture.

An appropriate mixture affords a permanent elongation after rupture of the order of 20—30% of the initial length of the specimen.

The properties of elongation at rupture and high elasticity can be obtained by making the mixture rich in elastomer, for example by providing the latter in the proportion of 50—65%.

c) The elastomers in the stretched state have a high sensitivity to ozone which tends to impair them. The mixture must therefore contain a proportion of agents neutralizing the harmful effect of ozone.

Among the known chemical compounds of utility for this purpose there may be mentioned:

A waxy body produced by the company NAUGATUCK under the trade name SUNPROOF IMPROVED. The proportions are 1—10 parts for 100 parts of elastomer.

Diamines such as N N′ Bis (1,4-diniethylpentyl) p-phenylene diamine sold by the Company Eastman C.P. Inc. under the name Eastozone 33. Proportions: 0.5—4 parts for 100 parts of elastomer.

The product sold under the trade name NAUGAWHITE (alkylated phenol), the proportion of which can be 0.5—5 parts for 100 parts of elastomer.

The following composition is given as an example of a mixture containing elastomer of advantage in the fabrication of an air mattress according to the invention.

Smoked crepe No. 1	80
GRS 1551	20
Zinc oxide	8
Utrasil VN 3	15
Suprex Clay	20
Zinc stearate	0.7
Paraffin	1
Calcinated light magnesium	1.5
Clear coumarone resin	2.5
Sunproof improved	8
Naugawhite (alkylated phenol)	4
Sulfur	0.8
Tetramethylthiurame disulfur	2
Colouring agent	2

The corresponding characteristics are given hereinafter:

Vulcanization time at 130°C	30 min.
Breaking strength in kg/sq.cm.	183
Elongation at rupture	839%
Permanent elongation after rupture	21%
Modulus of elasticity at 300%	17.5 K/sq.cm.

7) Results of tests.

In order to check the aforementioned theories and results of the calculations, curves were plotted as in Fig. 3 showing p′ as a function of p, on one hand, for a conventional mattress of inelastic cotton fabric coated with 27.27—50.50 (dotted line) and, on the other hand, for an elastic cotton-nylon fabric mattress (full line).

These curves, were plotted for loads which were 100 g, 200 g, 300 g respectively per centimeter of air compartment and were distributed over the whole of the mattress.

In another series of tests, the compressed mattress was in communication with a second mattress which was subjected to no load so as to represent the practical case of the sleeper lying on only a portion of the total area of the mattress. The results are not reproduced in the drawing but are comparable to those shown in Fig. 3.

8) Advantages.

To resume the preceding study and stress the improved comfort afforded by the mattress according to the invention, Fig. 4 represents the variation in the apparent weight of a sleeper weighing 100 kg on an air mattress as a function of the elasticity of the coated fabric. In this graph, the hatched portion indicates the range of values of α for the inflatable article according to the invention.

The following advantages can be added to the main advantage of an improved comfort:

Flexibility of the article. For example an elastic mattress more readily assumes the shape of the sleeper.

Possibility of special designs or particular reliefs.

Possibility of manufacturing a comfortable mattress for two people with a single inflating compartment, since, owing to the elastic fabric, the comfort of the first sleeper would be only

slightly affected by the movements of the second.

In the application to inflatable boats, not only is there an improvement in the comfort of the bottom of the boat but it is possible to provide new shapes. For example, by associating an elastic mattress with a conventional mattress it is possible to construct a curved wall.

In air mattresses and inflatable boats, it is possible partially to absorb accidental pressure variations due, for example, to the sudden dropping of a body or an increase in pressure due to heating subsequent to exposure to the sun.

As an illustration of the invention, the accompanying drawing shows an air mattress of rubberized elastic fabric.

In this drawing, given solely by way of example:

Fig. 5 is a plan view of the mattress;

Figs. 6—8 are sectional views taken along lines 6—6, 7—7, 8—8 respectively of Fig. 5, and

Fig. 9 is a diagrammatic view on an enlarged scale of the part of the mattress shown in Fig. 8 surrounded by the circle A, showing the construction of the wall of the mattress.

The air mattress shown in Fig. 5 comprises two independent inflating compartments corresponding respectively to the mattress body 1 and the pillow or cushion 2. Each of these parts is composed of two falls 3, 4, interconnected along their edges by the formation of a continuous peripheral lip or flange 5, and evenly-spaced transverse stays 6 extending between these edges which correspond to transverse sausage-shaped compartments are corrugations 7.

As can be seen in Fig. 8, the stays 6 are not connected to the respective walls along the entire length of their edges but only at intervals along short equally-spaced segments 8 in the conventional manner. Consequently all the chambers defined by the air compartments intercommunicate freely and the two walls form not only longitudinal corrugations 9 owing to the presence of the stays 6 but also transverse corrugations 11 formed between the segments 8.

Fig. 9 shows that in accordance with the invention the two walls 3 and 4 are constructed of a fabric comprising transverse elastic threads 12, for example of foam nylon, and longitudinal threads 13, which are slightly elastic and are composed for example of cotton, this fabric being covered on its inner face exposed to the mattress-inflating air with a coating or layer 14 of a mixture rich in rubber including at least one ingredient which renders the coating resistant to ozone.

The stays 6 can be composed of a rubberized fabric identical to that of the walls, but it can also be an inelastic coated fabric, in which case the discontinuous connection between the stays and the walls allows the latter to extend freely upon inflation in the transverse direction corresponding to the direction of the elastic threads 12.

Although specific embodiments of the invention have been described, many modifications and changes may be made therein without departing from the scope of the invention as defined in the appended claims.

WHAT WE CLAIM IS:—

1. An inflatable article such as an air mattress having its inside surfaces composed at least partially of a fabric coated with a layer containing an elastomer or plastomer, wherein the coated fabric is extendable in at least one direction according to a median extensibility coefficient α determined by the formula:

$$l_1 = l_o\ (1+\alpha f)$$

where l_o and l_1 represent the length of a unit with a segment of fabric measured in said direction respectively in the state of rest and in respect of a value f in kilograms of a traction force, α exceeding 0.05.

2. Article as claimed in claim 1, wherein the coating contains an elastomer and has a high elongation at rupture.

3. Article as claimed in claim 2, wherein the elongation at rupture is 500—900% and preferably of the order of 800%.

4. Article as claimed in claim 2, wherein the residual elongation after rupture is less than 30%.

5. Article as claimed in claim 2, wherein the proportion of elastomer in the coating mixture is between 50 and 65%.

6. Article as claimed in claim 2, wherein the coating composition comprises one or several agents imparting to the coating good resistance to ozone.

7. Article as claimed in claim 6, wherein the proportion of agents resisting ozone is between 0.5 and 10 parts for 100 parts of elastomer.

8. Article as claimed in any of claims 1 to 7 wherein α is between 0.05 and 0.5.

9. Article as claimed in claim 1, wherein if the pressure of utilization, corresponding to a zero initial pressure, is respectively h_c and h_E in respect of a mattress composed of an elastic fabric and a mattress composed of a fabric having the elasticity α, there is obtained:

$$h_E{}^3 = \frac{h_c{}^3}{1+2\ AR}$$

in which A is atmospheric pressure and R the initial radius of the air compartments of the mattress.

10. Article as claimed in claim 1, wherein the fabric is elastic in the direction corresponding to the smallest dimension of the article

and inelastic, or only slightly elastic, in the direction perpendicular to the last-mentioned direction.

11. Article as claimed in claim 1, wherein the fabric is a woven fabric, the weft thread being elastic and warp thread inelastic or only slightly elastic.

12. Article as claimed in claim 1, wherein one of the faces of the article is composed of elastic fabric and the other face of inelastic fabric.

13. An air mattress according to claim 1, comprising transverse elongated air compartments defined by stays interconnecting the two walls of the mattress, said stays being composed of a coated fabric which is identical to that of the walls and whose direction of elasticity is transversal.

14. An air mattress according to claim 1, comprising transverse elongated air compartments defined by stays interconnecting the two walls of the mattress, the edges of the transverse stays being connected to the respective walls along short spaced-apart segments.

15. Inflatable article, such as an air mattress, substantially as described and shown in the accompanying drawings.

MARKS & CLERK,
Chartered Patent Agents,
Agents for the Applicants.

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35

X MATERIALS

1968

1,128,764 COMPLETE SPECIFICATION
4 SHEETS

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 3 & 4

ELASTIC MATERIAL

Fig.5

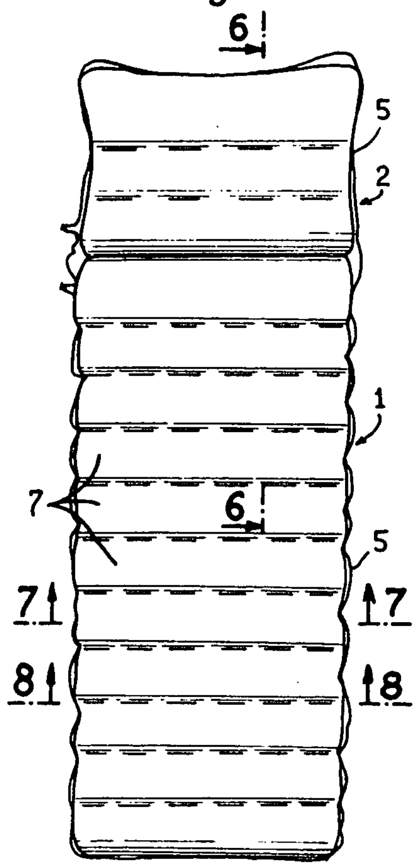


Fig.6

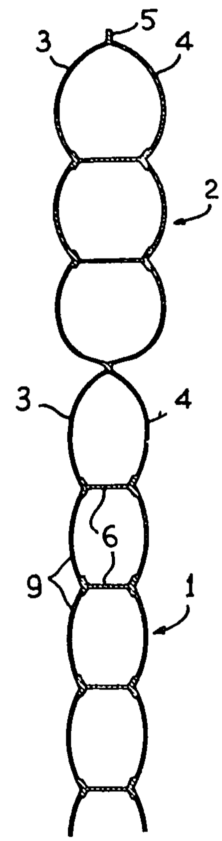


Fig.7

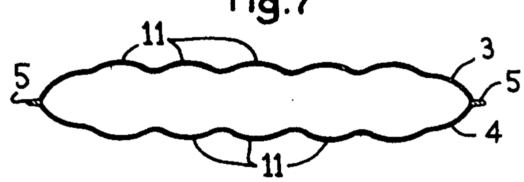


Fig.8

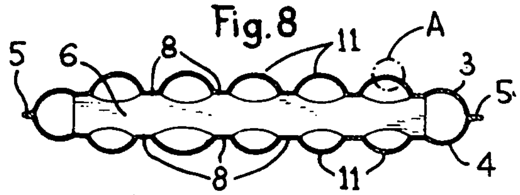
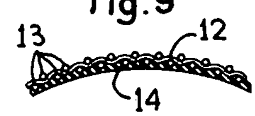


Fig.9



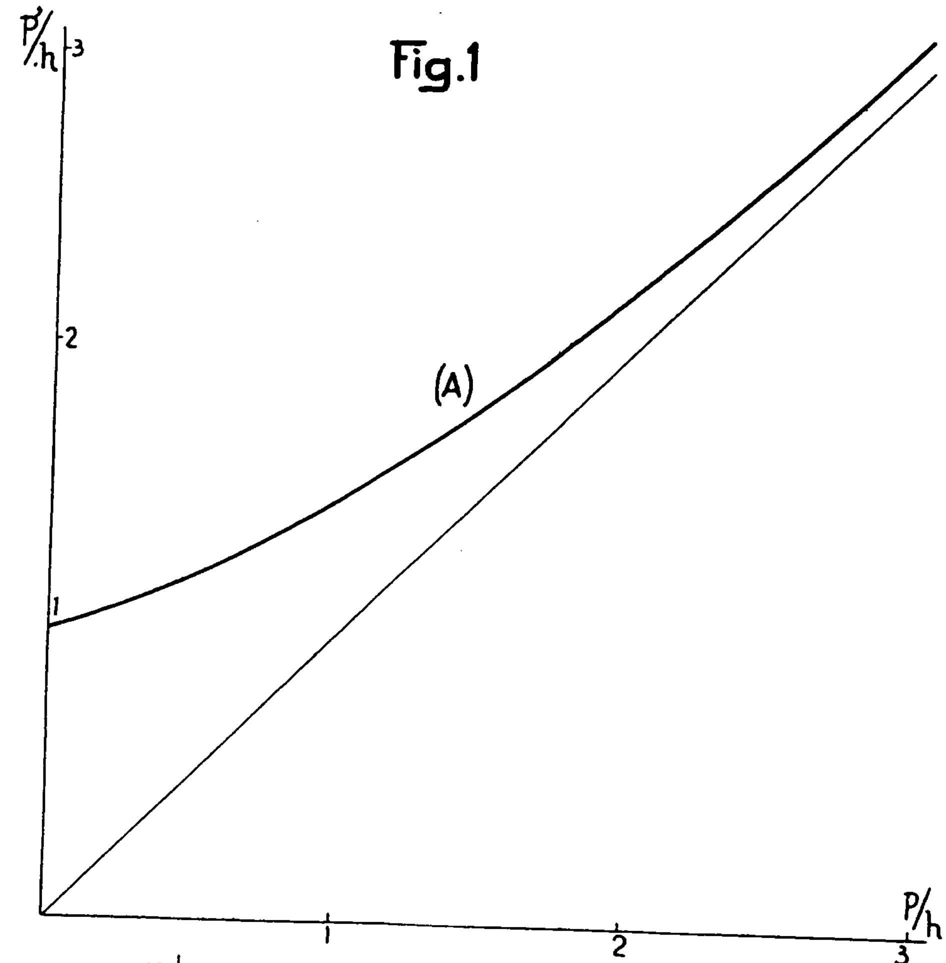


Fig.1

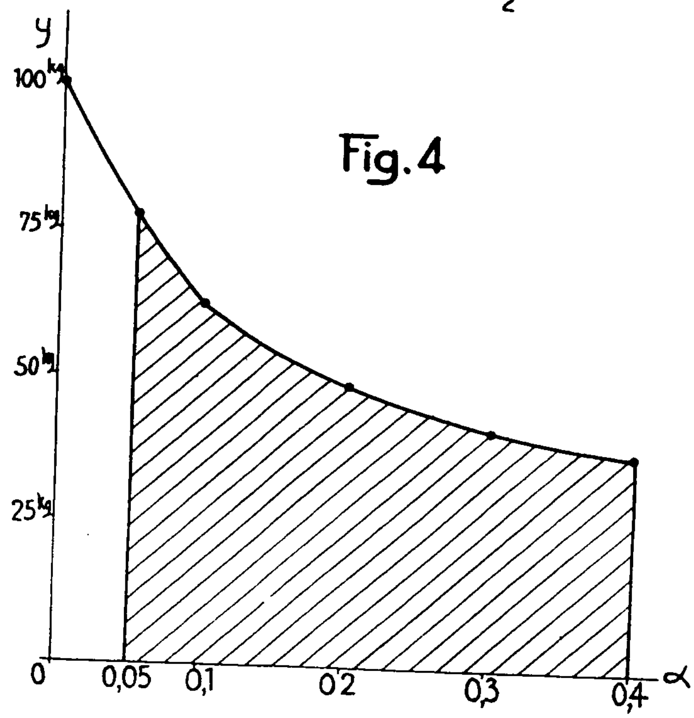
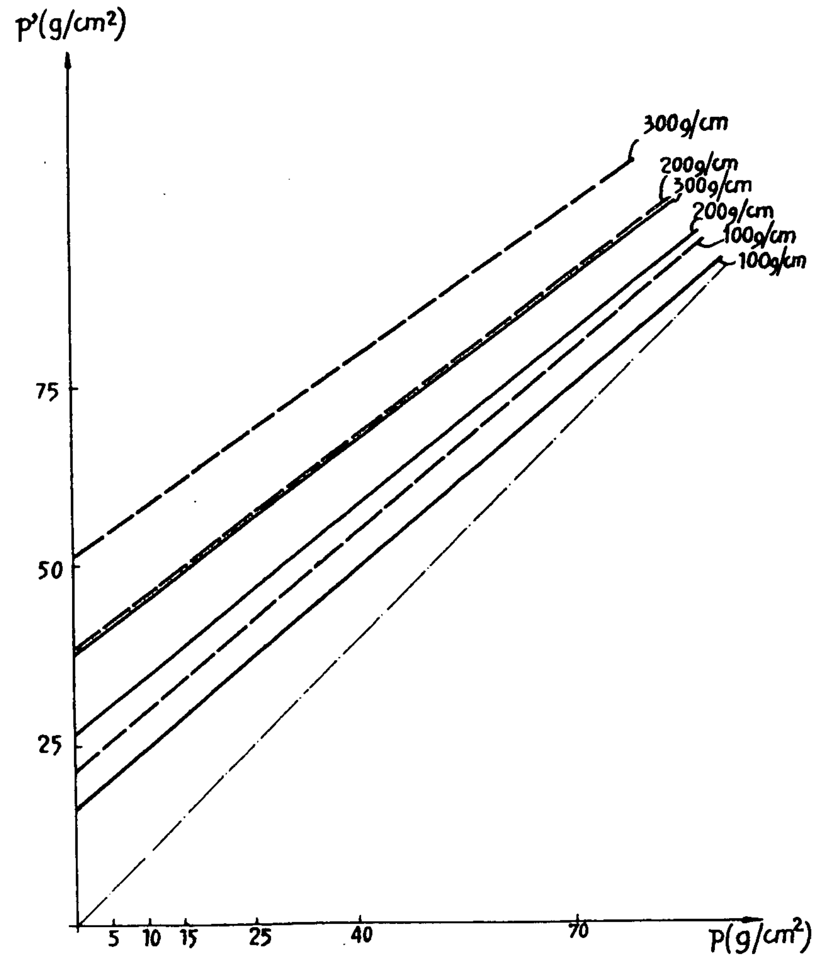


Fig.4

Fig.3



P'(g/cm²)
300g/cm
200g/cm
300g/cm
200g/cm
100g/cm
100g/cm
75
50
25
5
10
15
25
40
70
P(g/cm²)

1,128,764 COMPLETE SPECIFICATION
4 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

Fig.2